INTERNATIONAL TRANSLATION CENTER, INC.

ITC

DECLARATION OF TRANSLATOR

I, Lawrence B. Hanlon, of the International Translation Center, Inc., do hereby avow and declare that I am conversant with the English and German languages and am a competent translator of German into English. I declare further that to the best of my knowledge and belief the following is a true and correct translation prepared and reviewed by me of the document in the German language attached hereto.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of any patent issued thereon.

Lawrence B. Hanlon

Lawrence B. Hanlon

Date: 04/28/2005

1660 L STREET, N.W. • SUITE 613 • WASHINGTON, D.C. 20036 • TEL. (202) 296-1344

Hydac System GmbH, Industriegebiet, 66280 Sulzbach/Saar

Suspension Device

The invention relates to a suspension device for at least one drive part which is to be cushioned and which can be connected by means of a first valve unit to an accumulator device which is used for suspension in order to carry fluid, and which drive part can be connected by means of a second valve unit to a tank connection in order to carry fluid.

The pertinent suspension device is disclosed by EP-A-1 157 963. The known solution relates to a so-called wheel loader with a swiveling extension arm which moreover can also be changed in its length. To move the extension arm there is a hydraulic drive system with individual lifting or working cylinders, preferably one independently working cylinder as the drive part being assigned to each movable extension arm part. With the working cylinders of the hydraulic system it is therefore possible to actuate the swiveling motion for the extension arm and to change it by

retracting and extending in length, and by way of another working cylinder unit a tool which is located for example on the free end side of the extension arm, for example in the form of a load fork, can be actuated. Swiveling motion for the extension arm can be accomplished by way of a parallelogram drive in order to change the working height of the extension arm relative to the vehicle chassis according to the given working conditions for the wheel loader.

In addition to these drive means in the form of working cylinders, the hydraulic system in the known wheel loader design has a suspension device consisting of at least one hydraulic accumulator as an accumulator device and at least two actuatable valve units which make it possible to connect the accumulator device to the respective hydraulic cylinder or to the ambient pressure or tank pressure in the form of a tank connection for the suspension device. With this suspension device it is now possible, both with the drive part stopped to damp its natural motion, which is dictated for example by a load, and also to undertake damping when the drive part is being actuated, that is to say, in the known solution when the piston of the hydraulic cylinder consequently is extended or retracted. Thus, for example in the raised position of the extension arm under the load which is to be moved by means of a machine in the form of a wheel loader, the accompanying vibration movements on the extension arm can be damped by way of the known suspension device, the known solution providing for maintenance of the pertinent damping when the working cylinder and therefore the drive part are further actuated, for example to raise or lower the extension arm in this way.

Although the pertinent known solution leads to good damping and suspension behavior overall and on the whole enables a reliable operation of the hydraulic system for a wheel loader, problems can arise when the working cylinder which is to be cushioned as the drive part is in a definable load situation accompanied by the corresponding pressure level, especially on the piston side of the respective working cylinder, and as outlined when the suspension is connected by way of the respective hydraulic accumulator as the accumulator device when it does not have the same pressure level as the drive part used in the form of the respective working cylinder. Depending on the different pressure level, distinct transient and decay effects can occur when the suspension is connected to the respective working cylinder which can be considerable depending on the difference in level and which lead to deflection movements on the drive part which are critical in terms of safety engineering and accordingly on the mechanical component which is to be moved here, for example in the form of the indicated extension arm. Furthermore, due to the vibration processes rocking can unintentionally occur on the extension arm until the different pressure levels of the respective working cylinder and hydraulic accumulator have been equalized to one another. In addition to the already named safety risk, pressure spikes within the piping of the valve units can occur when the different pressure levels are matched, something that can damage the entire system of the tool.

On the basis of this prior art, the object of the invention is to further improve the known solution while retaining its advantages such that the described disadvantages do not occur,

especially safety risks and overloads in the hydraulic system are reliably avoided. This object is achieved by a suspension device with the features specified in claim 1 in its entirety.

In that, as specified in the characterizing part of claim 1, there is a pressure compensation device which when actuated equalizes the respective fluid pressure prevailing from the drive part and the accumulator device to one another for producing a common pressure level, it is possible, when the actual suspension is connected in the form of the accumulator device, to induce level compensation for the pressure beforehand in an extremely short time so that the suspension pressure used "is applied" exactly to the pressure of the respective drive part in the form of a hydraulic or working cylinder, which pressure the latter exhibits at that time due to the preceding load actuation processes. An unintentional extension and retraction movement of the piston rod part of the respective working cylinder which presents a danger for the surrounding area is thus reliably prevented and unintentional rocking motions do not occur either on the drive part and accordingly on mechanical components such as a extension arm or the like which are actuated and caused by the drive part. Since moreover in the solution as claimed in the invention the desired pressure level is immediately established, pressure spikes in the hydraulic system are avoided; this promotes a long service life of the overall hydraulic system. Furthermore, the solution as claimed in the invention is operationally reliable and economical to produce.

In one preferred embodiment of the suspension device as claimed in the invention, the pressure compensation device is mounted in a parallel connection to the two valve units and the

pressure compensation device has a compensator with control inputs which are connected on the one hand to the input side of the first valve unit in order to carry fluid, and on the other hand to the output side of the first valve unit.

In another preferred embodiment of the suspension device as claimed in the invention, the respective hydraulic accumulator of the accumulator device can be pressurized from the working cylinder by way of a check valve which is preferably integrated in the indicated first valve unit.

In this way, the hydraulic accumulator, for example in the form of a piston accumulator or comparable accumulator designs, is immediately charged with the initial pressure of the drive part and the pertinent pressure level in the hydraulic cylinder can be delivered for a suspension process on the working cylinder as soon as the necessary pressure compensation between the two partial systems is produced beforehand by way of the compensator. The respective hydraulic cylinder then immediately is applied to the compensated pressure level of the hydraulic accumulator and dangerous displacement or rocking motions for the drive part in the form of the working cylinder are thus reliably precluded.

Other advantageous embodiments are the subject matter of the other dependent claims.

The suspension device as claimed in the invention will be detailed below using the single drawing which shows the configuration of the suspension device as claimed in the invention in a schematic diagram.

The suspension device as claimed in the invention is designed for at least one drive part 10 which is to be cushioned and has at least one accumulator device 12 which is used for suspension. The drive part 10 consists of a conventional working or hydraulic cylinder 14 with a piston part 16 and rod part 18 which divides the working cylinder 14 into two fluid-carrying working spaces 20, 22, and depending on the amount of fluid held in the working space 20, 22, a definable position for the piston rod part 16, 18 arises therefrom.

Thus the working space 20 is connected by way of a first connecting line 24 to the input 26 of a first valve unit 28 in order to carry fluid, and the other, second working space 22 is according connected to the input 32 of the second valve unit 34 by way of a second connecting line 30 in order to carry fluid. The indicated two valve units 28 and 34 represent conventional electrically actuatable 2/2-way switching valves which in the unactuated, spring-loaded state assume a blocked position at least in one fluid direction of the respective valve. Thus the first valve unit 28 in its unactuated, spring-loaded initial position is blocked in the direction of its input 26 by way of an integrated check valve 36 which can be moved in the direction of the output 38 of the first valve unit 28 into its open position. As the figure furthermore shows, conversely the two check valves 40, 42 which are blocked against one another are arranged flat such that in the unactuated initial position of the

second valve unit 34, fluid blocking takes place in two directions, that is to say, in the direction of the input 32 to the output 44 of the second valve unit 30 and also in the reverse direction. Furthermore, the indicated output 44 of the second valve unit 34 is connected in order to carry fluid to a tank connection 46 which leads to the tank system of the hydraulic system for which the suspension device as claimed in the invention is designed. Instead of the integrated check valve 36 in the first valve unit 28, this check valve in an embodiment of the connection which will not be detailed can be connected parallel to the valve unit 28 and may be provided with one fluid-carrying connection each in front of the input 26 and the output 38, the check valve in turn assuming its open position in the direction of the output 38. In the pertinent case the first valve unit 28 is provided with two check valves which can be unblocked in opposite directions, like the illustrated second valve unit 34. This has the advantage that valve units 28, 34 with the same configuration can be used to implement the switching.

In the parallel connection 48 to the two indicated valve units 28, 34, there is a pressure compensation device designated as a whole as 50 which in the actuated state equalizes the respective fluid pressure prevailing from the drive part 10 (hydraulic cylinder) and from the accumulator device 12 (hydraulic cylinder) to one another. The already cited accumulator device 12 generally consists of a hydraulic accumulator or hydraulic cylinder 52, for example in the form of a piston accumulator or the like. The use of hydraulic accumulator assemblies for cushioning and damping of movements in working cylinders is known in the prior art (cf. EP-A-1 157 963) and the pertinent assemblies can also be used for "energy recovery", in which it is provided that hydraulic

energy is delivered into the hydraulic accumulator in one working motion of the working cylinder and is then intentionally retrieved from there if the hydraulic cylinder is moved in the opposite direction. In this way energy savings can be achieved to the relevant extent in the operation of machinery with hydraulic working cylinder devices.

If the pressure compensation means 50 is mounted in a parallel connection 48 to the two valve units 28, 34, this means that two other connecting lines 54, 56 lead away from the output 38 of the first valve unit 23 and from the output 44 of the second valve unit 34, and that between the two pertinent connecting points 58 in a branch line 60 which connects the connecting parts 58 there is a pressure compensation device 50 which consists essentially of a compensator 62. A compensator is conventionally defined as a valve component which is designed to keep the volumetric flow which is given by a metering choke constant, even when the load pressure fluctuates. To do this, the compensator operates in an internal control circuit as a differential pressure regulator with a movable control edge which can be changed such that the pressure difference on the metering orifice is always constant, regardless of the prevailing load pressure. Here the compensator 62 can be connected upstream of the metering choke 64, as shown in the illustrated embodiment. Moreover the compensator 62 has two control inputs 66, 68, and the control input 66 can be actuated by way of another choke 70 by the fluid pressure at the input 26 of the first valve unit 28 and the second control input 68 on the opposite side of the compensator 62 can be actuated by the fluid pressure prevailing in the third connecting line 54 to which the hydraulic accumulator 52 is also connected by way of an orifice 72 in order to carry fluid. The input side 74 to

which the second control input 68 is connected is consequently connected by way of the third connecting line 54 to the output side 38 of the first valve unit 28, in turn the output side 76 of the compensator 62 being connected preferably by way of the metering choke 64 to the input 78 of the third valve unit 80 with an output 82 which is connected in turn to the tank connection 46 in order to carry fluid.

The three indicated valve units 28, 34 and 80, together with the compensator 62 and a pressure limitation valve 84 which can be set to a definable pressure and which in turn in a parallel connection to the compensator 62 protects the respective hydraulic accumulator 52 against an overpressure, as a suspension control block 86 form a retrofittable functional unit which accordingly can be used subsequently even for existing, delivered machinery of any type, if for different systems their suspension comfort and safety are to be improved. Between the branch line 60 and the pressure limitation valve 84 which is mounted in a parallel connection, in turn connected parallel to the pressure compensation means 50 there is a shutoff valve 88, by way of which the pressure from the hydraulic accumulator 52 can be released, for example for carrying out maintenance.

Furthermore, for the respective drive part 10 there is a control block which is designated as a whole as 90 and which, as is conventional in the prior art (EP-A-1 157 963), by way of two control lines 92, 94 ensures the primary function for the drive part 10, specifically enables actuating for the extension and retraction of the piston rod part 16, 18 of the working cylinder 14. Thus, for the corresponding actuation of the control block 90, pressurized fluid is moved into the working space

20 of the working cylinder 14 and in this way the piston rod unit 16, 18 is raised. The fluid which is excess in the other working space 22 is returned with the pertinent lifting motion to the control block 90 by way of the other control line 92. For the lowering motion of the piston rod unit 16, 18, the pertinent process can be reversed and the excess fluid on the working space side 20 then travels by way of the control line 94 back into the control block 90, and, depending on the applied load situation, the pertinent return process can also be supported by the corresponding fluid pressure which prevails at the first control line 92.

For the sake of better understanding, the operation of the suspension device as claimed in the invention will be detailed below using one working example.

With the suspension disengaged or blocked, the loading of the extension arm-lifting cylinder 14 can be changed by altering the length of the telescoping extension arm and by loading or unloading a load shovel or load fork (not shown). Then, provision is made such that in the subsequent activation of the suspension, undefined movements which are caused by the different level pressure which is blocked in the respective hydraulic accumulator 52 relative to the working cylinder 14 are avoided.

For this reason, the hydraulic accumulator 52 is permanently connected by way of the check valve 36 to the working space 20 of the piston side 16 of the working cylinder 14 and is thus charged with the maximum pressure occurring in the respective working play with the working

cylinder 14. Before activation of the suspension, the third valve unit 80 is briefly opened at this time, so that at this instant the compensator 62 can release the pressure from the hydraulic accumulator 52 to the level of the current pressure on the piston side of the working cylinder 14. Immediately afterwards the valve 80 is in turn closed.

To activate the suspension, by opening the first valve unit 28 which can be regarded as a type of suspension-shutoff valve, the latter is moved into the opened, fluid-carrying valve position and thus the piston side of the working cylinder 14 is connected to the hydraulic accumulator 52. The rod side, that is to say, the working space 22 of the working cylinder 14, is then connected to the tank connection 46 and accordingly to the tank by simultaneous opening of the second valve unit 34 which is configured as a prefill valve. The suspension which has been activated in this way can then also be maintained in operation of the working cylinder 14 in which the piston rod unit 16, 18 within the cylinder housing changes in its position. If the prefill valve 34 is closed, and to activate the suspension the suspension shutoff valve 28 is opened, by way of the control block 90 the working cylinder 14 can be moved for the retraction and extension processes of its piston rod part 16, 18, the fluid pressure then prevailing in the two control lines 92, 94 providing for a fluid flow being established between the working space 20 of the hydraulic cylinder 14 and the control block 90, by way of the second control line 94.

In that, in terms of the solution as claimed in the invention, the hydraulic accumulator 52 is pressurized from the working cylinder 14 by way of a check valve 36 and because before activation

of the suspension the pressure between the hydraulic accumulator 52 and the working cylinder 14 is compensated by way of the compensator 62, undefined movements of the actuated mechanical parts of a working device or machine, such as a telescoping loader, which movements adversely affect safety, are reliably prevented and pressure spikes which damage the hydraulic system are likewise avoided by the gentle unblocking and connection of the suspension pressure.